USING VOLTAGE REFERENCE AND TEMPERATURE SENSOR ICs (Part 1)

by Ray Marston

Ray Marston shows – in this opening episode of this new three-part series – how to use various popular 'voltage reference' ICs.

This new three-part series looks at practical applications of various precision 'voltage reference,' 'current source,' and 'temperature sensor' ICs. Most of the ICs specified in the series are commercial-grade types, manufactured by National Semiconductor and various other companies, and are widely available; most of them are also made in 'industrial' and 'military' grades, with greatly enhanced specifications. This opening episode of the series deals exclusively with modern voltage reference ICs.

VOLTAGE REFERENCE IC BASICS

Voltage reference ICs are simple units that house a precision temperature-compensated voltage reference device and an output buffer stage. The reference can be of the 'band-gap' type, which generates a stable low-noise output of (usually) about 1.22V, or of the 'subsurface zener' type, which (in modern devices) usually generates a stable output of about 6.9V.

The output buffer acts as a current-boosting (and sometimes voltage amplifying) regulator, and may be of either the shunt or the series type. ICs with shunt outputs can normally be used in exactly the same way as a simple zener diode voltage regulator. *Figure 1* gives basic details of five popular 'commercial-grade' voltage reference ICs manufactured by National Semiconductor. Details of these five ICs are as follows:

Device number	V_{ref}	Voltage tolerance at +20°C	Drift PPM/°C (max)	Reference operating current
LM329B	6.9V	±5%	50	0.6-15mA
LM336B - 2.5	2.49V	±2%	54	0.4-10mA
LM385	Adjustable (1.235V-5.3V)	±2%	54	13µA-20mA
LM385 - 1.2	1.235V	±2.4%	150	15µA-20mA
LM385 - 2.5	2.5V	±3.0%	150	20µA-20mA

Figure 1. **Voltage reference IC selection chart (National Semiconductor 'commercial-grade' shunt-output devices, with 0-70°C operating range).**

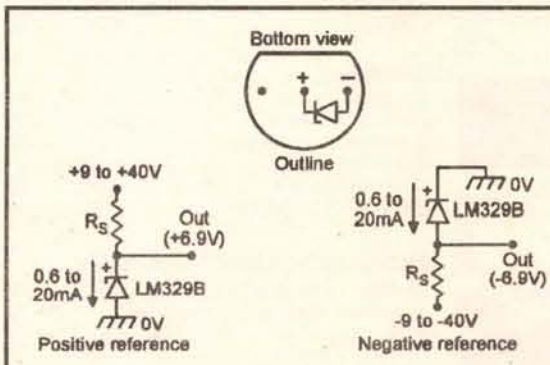


Figure 2. **LM329B outline and basic reference circuits.**

The LM329B

The LM329B is a low-cost zener-based precision 6.9V reference that can operate over the full 0.6mA to 15mA current range. It is usually housed in a three-pin plastic package, as shown in *Figure 2*, which also shows basic ways of using the device as a positive or a negative 6.9V reference. In these circuits, the Rs value is chosen to set the desired operating current, as in a normal Zener diode. *Figure 3* shows a simple way of boosting the LM329B output via a non-inverting op-amp stage to make a 10V reference generator (a precise 10V can be set by trimming the *Cal* control).

The LM336B-2.5

The LM336B-2.5 is a low-cost band-gap based precision 2.5V (nominally 2.49V) reference voltage generator and is housed in a three-pin TO-92 plastic package; *Figure 4* shows the IC's outline

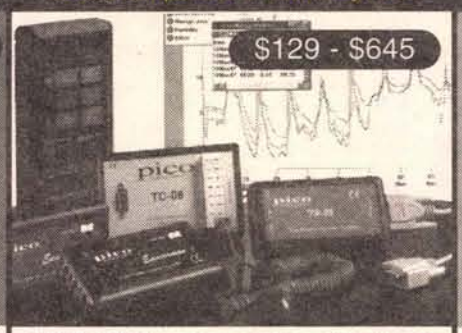
Use your PC as a scope and datalogger!

PC-based Instruments!

Parallel Port Scope
spectrum analyzer, and digital multimeter

ADC Virtual Instruments turn your PC or laptop into a sophisticated storage scope AND spectrum analyzer AND multimeter. Display simultaneously on large screen! 100MS/s 8-bit or 1.2MS/s 12-bit or 333kS/s versions. Great for schools, test depts, etc. Input to Excel! LabView/NT drivers included.

Environmental Logging
record temperature, humidity, etc.



ENVIROMON - temperature (thermistor), humidity & light sensors, door position, etc. Record for 365/24 without a PC even if power fails. Monitor 30 sensors 400 yds away. With cables and easy software. Remote audio alarm. Use **TC-08** for most thermocouples.

osziFOX
20MS/s handheld scope

osziFOX - handheld storage scope and DVM - stand-alone or plugs into your PC for display, store-to-disk, printing in color. Inputs to 100V, trigger, backlit LCD.

Download FREE demo software. Sales only: 1-888-7SAELIG
www.saelig.com 716-425-3753 • -3835 (fax) saelig@aol.com

pico Technology Limited ®

Stocked in NY by Saelig Company: Virtual Instruments, I2C and embedded controllers, BITlink 2-wire networks, RS232/422/485, frame grabbers, etc. See www.saelig.com for Product of the Month!

Write in 59 on Reader Service Card.

USING VOLTAGE REFERENCE AND TEMPERATURE SENSOR ICs

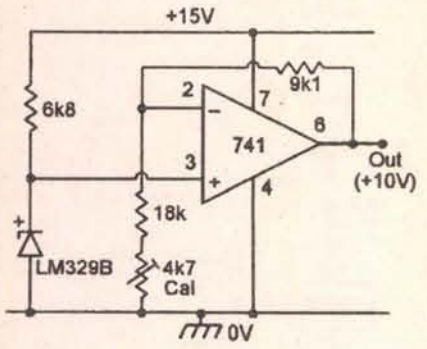


Figure 3. **Buffered 10.0V reference with single-ended supply.**

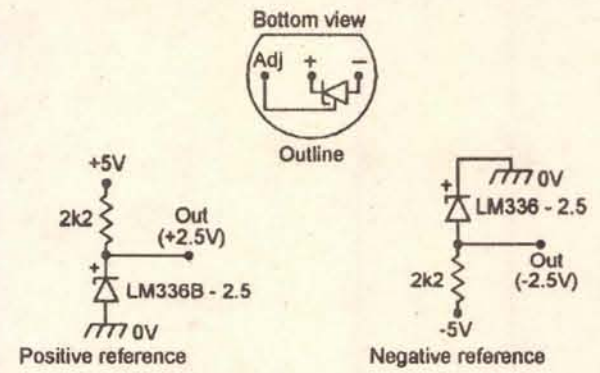


Figure 4. **LM336B-2.5 outline and basic reference circuits.**

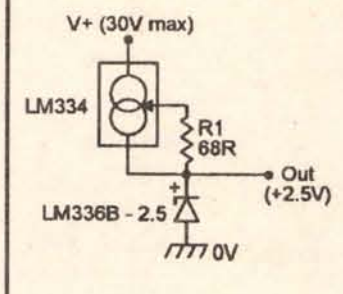


Figure 6. **LM336B-2.5 voltage reference, using a wide supply voltage range.**

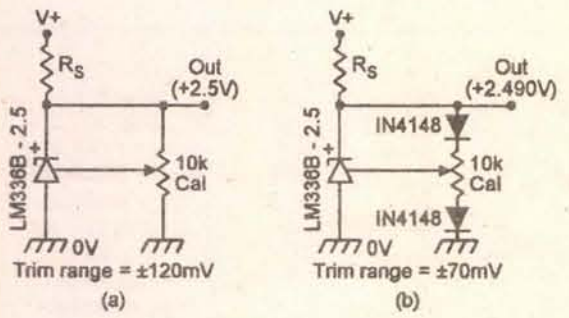


Figure 5. **LM336B-2.5 'trim' circuits to give (a) voltage and (b) temperature coefficient compensation.**

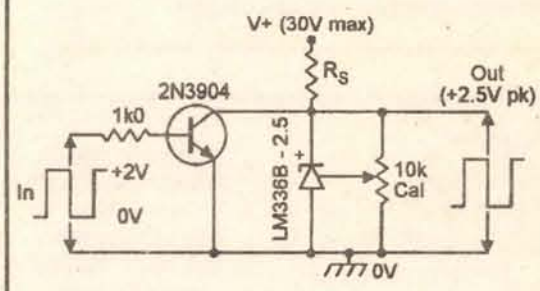


Figure 7. **LM336B-2.5 squarewave voltage calibrator generator circuit.**

and basic usage circuits. The IC's third pin can be used to either trim the output voltage by about ±120mV, as shown in *Figure 5(a)*, or to trim the IC for minimum temperature coefficient (in which case, the output must be set to 2.490V), as shown in *Figure 5(b)* (where D1 and D2 must share the same thermal environment as the LM336B-2.5 IC).

Note that the LM336B-2.5 can be operated from a widely variable supply voltage (up to 30V maximum) by feeding it via an LM334 constant-current generator IC (described in detail in next month's episode of this mini-series), as shown in *Figure 6* (where R1 sets the constant-current value at 1mA).

Figure 7 shows how the LM336-2.5 IC can be used — in conjunction with an external squarewave generator — to make a squarewave 'voltage calibration' generator for use in oscilloscopes, etc.

In this circuit, the 2N3904 transistor shunts the LM336-2.5 IC, and is alternately driven fully on (saturated) and fully off via the external squarewave generator (which usually operates at 1kHz and can thus provide a 1mS timebase calibration function); the variable *Cal* control is trimmed to give an accurate 2.5V peak-to-peak squarewave output.

The LM385- series

The National Semiconductor LM385- series of ICs combine a band-gap reference and a shunt booster to make 'micropower' devices that can operate at currents ranging from a few microamps to 20mA. There are three basic devices in the series: the LM385-1.2 is housed in a TO-92 package and generates 1.235V output; *Figure 8* shows the ICs outline and basic application circuits. The LM385-2.5 is housed in the same type of TO-92 pack-

BIG POWER
LOW COST

Dominos are rugged, miniature encapsulated controllers that com- bine lots of analog and digital I/O with a fast control-oriented floating-point BASIC to provide a one-stop computation and control solution for cost-sensitive control tasks. Used stand alone or connected via RS-232/RS-485, Dominos are true plug-and-go control.

Domino 1 features:
- Full floating-point ROMed BASIC
- 32-KB SRAM and 32-KB EEPROM
- 12 bits of parallel I/O
- 2 PWM outputs
- I²C bus
- 2-channel 12-bit ADC
- Serial port: 19.2-kbps RS-232A, RS-422, or RS-485
- +5 V @ 15 mA

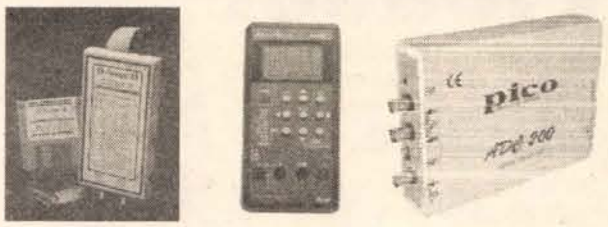
Domino 2 has:
- **everything in Domino 1 plus**
- 16 more bits of high-current parallel I/O
- Hardware clock/calendar
- Wide-range power operation
- Hardware PWM output

$99 to $139

Visit our Web site for complete datasheets
www.micromint.com
To Order Call: **1-800-635-3355**
Micromint, Inc
740 Florida Central Pkwy., Longwood, FL 32750
(407) 262-0066

Write in 61 on Reader Service Card.

Test Equipment
From $99.00



ATC modules provide for affordable pc based testing
DSO, DVM, Spectrum Analyzer, Data Logging
O-Scope Ip and O-Scope II Single and dual channels
Serial a protocol analyzer software package
DFA 5 low cost differential amplifier

Standalone digital oscilloscopes from **HiRel** and **TPI**

Pico Technology LTD leads in low cost pc based modules for test and data logging. Units to 100MSPS. 8 to 16 bits, 1 to 22 channels. Environmental monitoring. Science education with **DRDAQ.** Pricing from $99

Allison Technology Corporation
2006 Finney Vallet Rd. Rosenberg, TX 77471
PH: 800-980-9806 or 281-239-8500, FAX 281-239-8006
http://www.atcweb.com atc@atcweb.com

USING VOLTAGE REFERENCE AND TEMPERATURE SENSOR ICs

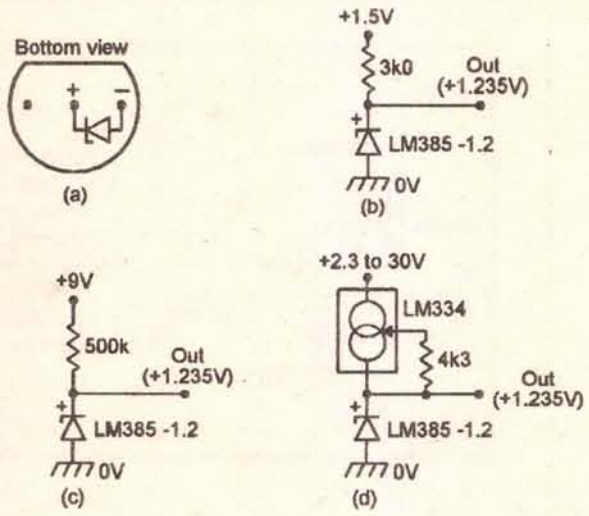


Figure 8. **LM385-1.2 outline (a) and basic circuits showing (b) reference from 1.5V battery, (c) micropower reference from 9V battery, and (d) reference from wide supply voltage range.**

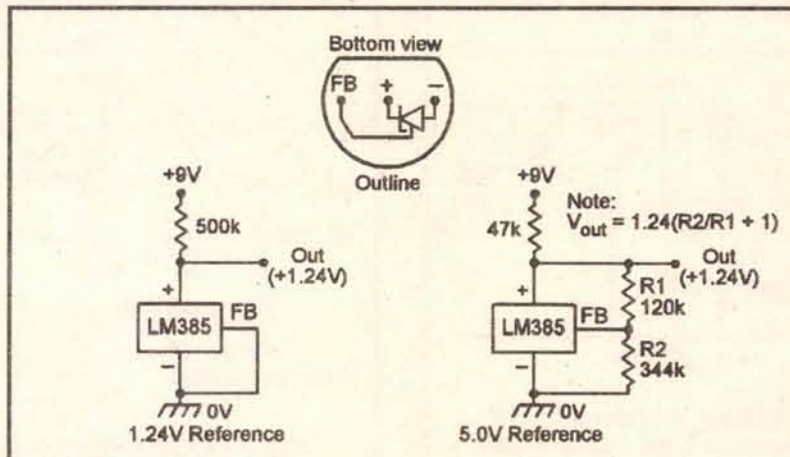
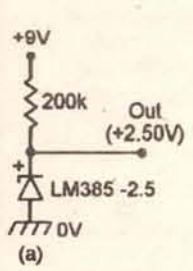


Figure 10. **LM385 outline and basic application circuits.**



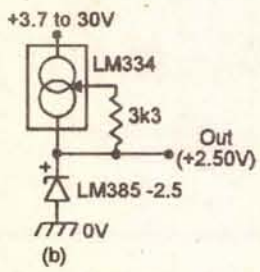


Figure 9. **Basic LM385-2.5 circuits showing (a) micropower reference from 9V supply and (b) reference from a wide-range supply.**

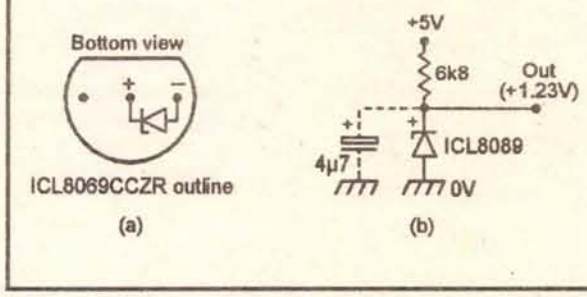


Figure 11. **ICL8069CCZR outline (a) and basic ICL8069 application circuit (b) as a 1.23V reference generator.**

age and generates a fixed 2.5V output; *Figure 9* shows two basic usage circuits for this IC. Finally, the plain 'LM385' is a three-pin version that can be adjusted, via its FB (feedback) terminal, to give a precision 'micropower' reference in the range 1.235V to 5.3V; *Figure 10* gives details of this device.

Note in the *Figure 8(d)* and *9(b)* circuits that the LM344 device is an adjustable constant-current generator IC, and will be described in some detail in Part 2 of this mini-series.

MISCELLANEOUS VOLTAGE REFERENCE ICs

Several companies other than National Semiconductor manufacture popular types of voltage reference ICs. Among the best known of these are Harris Semiconductor, SGS-Thomson, and Analog Devices. The remaining sections of this month's article briefly describe the most popular voltage reference ICs produced by these three manufacturers.

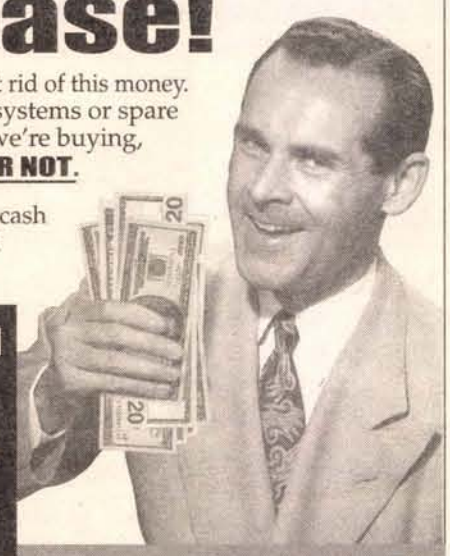
The ICL8069 (Harris Semiconductor)

The ICL8069 is a temperature-compensated band-gap voltage reference IC with a typical output voltage of 1.23V at an operating current of 500µA. The IC's operating current can be varied over the range 50µA to 5mA, and its output voltage typically shifts by only 15mV when the current is varied over this range. The ICL8069 is

Take Our Cash... Please!

We've gotta get rid of this money. If you've got systems or spare parts to sell, we're buying, **WORKING OR NOT.**

We'll swap ya cash for drives and RAM, too!



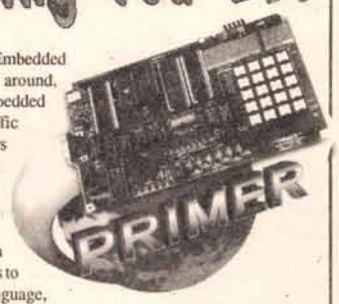
Compaq H-P IBM Toshiba Sony Apple

Contact Arthur today at: **Pre-Owned Electronics** INCORPORATED

800-274-5343 X4310

or email: ajr@preowned.com DIS0089

World Passing You By?



Are you interested in Microprocessors & Embedded Control Systems? If not you should be! Look around, just about everything these days has an embedded microprocessor in it. TVs, cars, radios, traffic lights & even toys have embedded computers controlling their actions. The Primer Trainer is the tool that can not only teach you how these devices operate but give you the opportunity to program these types of systems yourself. Examples & exercises in the Self Instruction manual take you from writing simple programs to controlling motors. Start out in Machine language, then move on to Assembler, & then continue on with optional C, Basic, or Forth Compilers. So don't be left behind; this is information you need to know!

Examples Include:

- Measuring Temperature
- Using a Photocell to Detect Light Levels
- Making a Waveform Generator
- Constructing a Capacitance Meter
- Motor Speed Control Using Back EMF
- Interfacing and Controlling Stepper Motors
- Scanning Keypads and Writing to LCD/LED Displays
- Bus Interfacing an 8255 PPI
- Using the Primer as an EPROM Programmer
- DTMF Autodialer & Remote Controller (New!)

The PRIMER is only $119.95 in kit form. The PRIMER Assembled & Tested is $169.95. This trainer can be used stand alone via the keypad and display or connected to a PC with the optional upgrade ($49.95). The Upgrade includes: an RS232 serial port & cable, 32K of battery backed RAM, & Assembler/Terminal software. Please add $5.00 for shipping within the U.S. Picture shown with upgrade option and optional heavy-duty keypad ($29.95) installed. Satisfaction guaranteed.

EMAC, inc.

11 EMAC WAY, CARBONDALE, IL 62901
618-529-4525 Fax 457-0110 BBS 529-5708
World Wide Web: http://www.emacinc.com

1985 - 1998 OVER 12 YEARS OF SERVICE

Write in 60 on Reader Service Card.

USING VOLTAGE REFERENCE AND TEMPERATURE SENSOR ICs

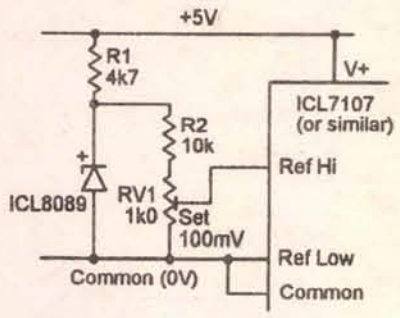


Figure 12. **Basic ICL8069 100mV reference generator for a DVM IC circuit.**

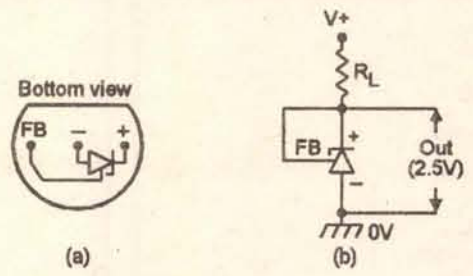


Figure 13. **TL431CZ outline (a) and basic application circuit (b) as a 2.5V reference generator.**

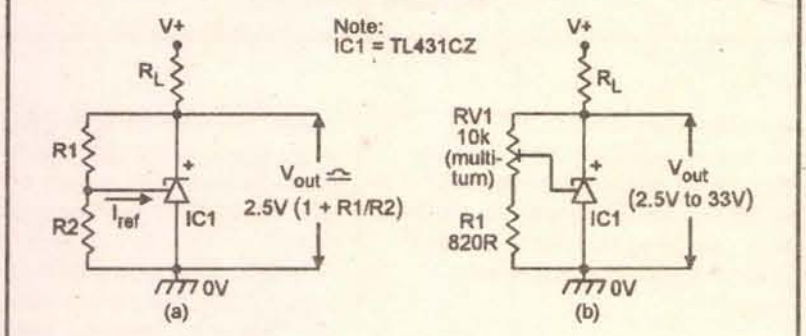


Figure 14. **Basic TL431CZ application circuits as (a) a programmable reference voltage generator and (b) a variable reference voltage generator.**

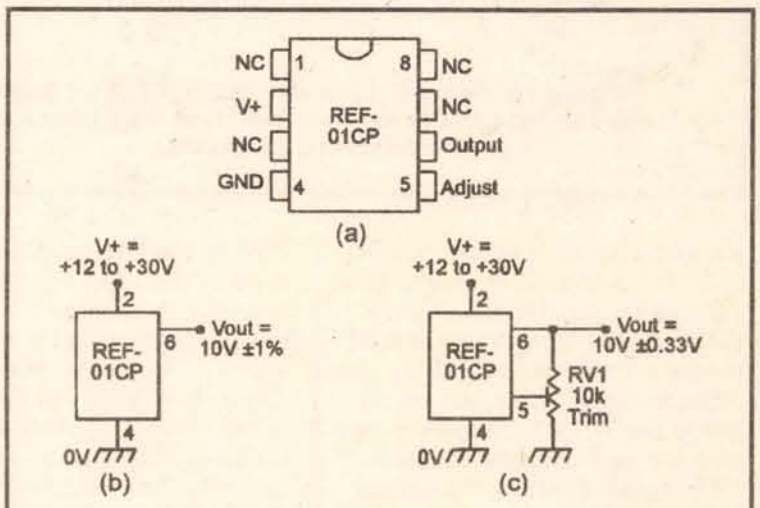


Figure 15. **Outline (a) of the REF-01CP, plus basic application circuits as (b) a fixed and (c) a trimmable 10V reference generator.**

produced in eight sub-types (each defined by a four-letter suffix). The best known of these is the ICL8069CCZR, which is housed in a TO-92 plastic package, can be used over the full 0 to 70°C temperature range, and has a typical output voltage temperature coefficient of 0.005%/°C.

Figure 11 shows the IC outline that is specific to the ICL8069CCZR, together with the basic application circuit that applies to all ICs in the ICL8069 range. This particular application circuit is designed for use with a 5V supply. The 6K8 resistor sets the IC's operating current at a nominal value of 550µA. The optional 4µ7 capacitor can be used to enhance circuit stability if the IC's output is loaded by capacitances in excess of 200pF.

Finally, *Figure 12* shows the basic ICL8069 IC used as a 100mV reference voltage generator for use in an ICL7107 (or similar) DVM (digital voltmeter) IC circuit. RV1 must be trimmed to set a precise 100mV output between the DVM IC's *Ref Hi* and *Ref Low* input terminals.

The TL431CZ (SGS-Thomson)

The TL431CZ is a temperature-compensated band-gap voltage reference IC with a programmable shunt output that can be set to any value between 2.5V and 36V via two external resistors. The IC is housed in a three-pin TO-92

The Standard for checking Capacitors in-circuit

Good enough to be the choice of Panasonic, Pioneer, NBC, ABC, Ford, JVC, NASA and thousands of independent service technicians.

Inexpensive enough to pay for itself in just one day's repairs. At $179, it's affordable.

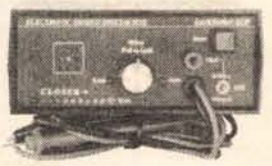
And with a 60 day trial period, satisfaction guaranteed or money-back policy, the only thing you can lose is all the time you're currently spending on trying to repair all those dogs you've given up on.

CapAnalyzer 88A

Locate shorted or leaky components or conditions to the exact spot *in-circuit*

Still cutting up the pcb, and unsoldering every part trying to guess at where the short is?

$179



Your DVM shows the same shorted reading all along the pcb trace. LeakSeeker 82B has the resolution to find the defective component. Touch pads along the trace, and LeakSeeker beeps highest in pitch at the defect's pad. Now you can locate a shorted part only a quarter of an inch away from a good part. Short can be from 0 to 150 ohms

LeakSeeker 82B

***Available at your distributor, or call* 561-487-6103**

Electronic Design Specialists www.eds-inc.com

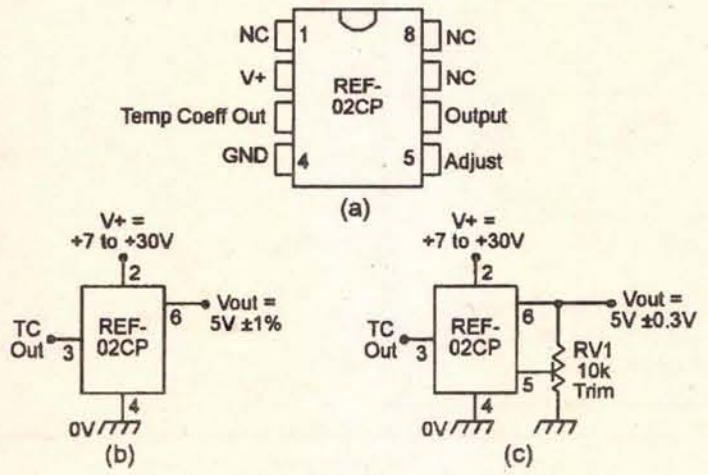


Figure 16. **Outline (a) of the REF-02CP, plus basic application circuits as (b) a fixed and (c) a trimmable 5V reference generator.**

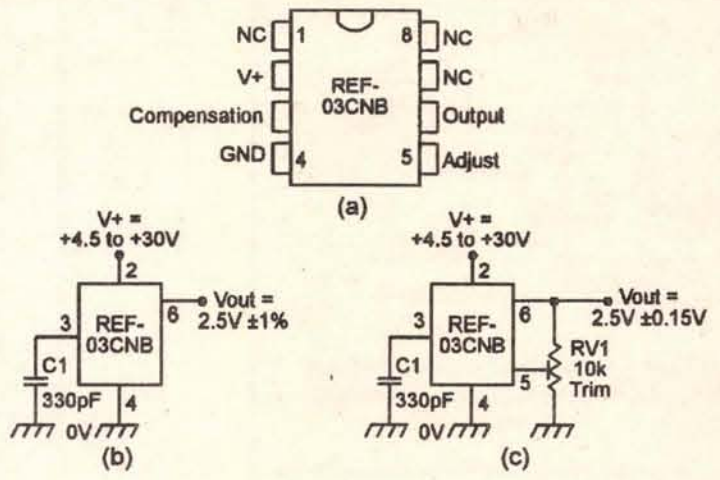


Figure 17. **Outline (a) of the REF-03CNB, plus basic application circuits as (b) a fixed and (c) a trimmable 2.5V reference generator.**

package, can be used over the full 0 to 70°C temperature range, and can (within sensible power dissipation limits) be operated at load currents in the range 1mA to 100mA. *Figure 13* shows the outline of the TL431CZ, together with its basic application circuit as a 2.5V (nominal) reference voltage generator.

Figure 14(a) shows how to use the TL431CZ as a programmable reference voltage generator in which the output voltage can (when the IC is powered from an adequate supply source) be set at any value within the range 2.5V to 36V via the R1/R2 potential divider. The basic V_{out} formula shown in this diagram is valid if the current flowing through the series-connected R1/R2 potential divider is at least 100 times greater than I_{bias}, which has a maximum value of 5.2µA (1.8µA typical). Thus, to generate a 10V output, R1 must equal 3xR2, and the R1/R2 combination must have a total resistance of less than 20K.

Finally, *Figure 14(b)* shows how to use the TL431CZ as a variable reference voltage generator, in which the output voltage is fully variable from 2.5V to 33V via multi-turn pot RV1. Note in both *Figure 14* circuits that the R_L value should be chosen to set the IC's operating current to 1mA or greater (0.5mA absolute minimum).

The REF-0x series (Analog Devices)

Analog Devices manufacture a variety of precision voltage reference ICs, the best known of which are their 'REF-0x' series of laser-trimmed band-gap devices with short-circuit proof outputs. There are three basic ICs in the series: the REF-01 type generates a basic output of 10V, the REF-02 type generates an output of 5V, and the REF-03 type generates an output of 2.5V. In all cases, the output voltage has a basic precision of ±1%; the output voltage can, however, easily be externally trimmed (by up to ±3.3% in the REF-01, and up to ±6% in the REF-02 and REF-03) via an external 10K pot. Note that the REF-02 provides a regular 5V output, plus an additional high impedance temperature-sensitive 'temperature coefficient' (TC) output voltage that changes linearly from 577.5mV at 0°C to 724.5mV at 70°C.

The REF-01, REF-02, and REF-03 are each produced in a number of sub-types (each defined by a multi-letter suffix), offering a variety of packaging and parameter options. The most popular of these ICs are the REF-01CP, the REF-02CP, and the REF-03CNB, which are each housed in an eight-pin plastic package, can be operated over the full 0 to 70°C temperature range, draw a basic operating current of 1mA, can provide up to 20mA of output load current, and consumes a self-limiting current of 30mA under shorted-output operating conditions.

Figures 15 to *17* show the IC outlines and basic application circuits of the REF-01CP, the REF-02CP, and REF-03CNB. In each case, diagram (b) shows the IC used in its basic (fixed output voltage) operating mode, and diagram (c) shows it used in the trimmable output mode. Note in *Figure 16* that the temperature-sensitive 'TC' output of the REF-02CP is provided on pin 3 of the IC. **NV**

Learning made easy with CIE's Bookstore!

Basic PC Learning Course

This self-study course will allow you to:

- Understand Basic PC Principles
- Diagnose PCs
- Repair PCs
- Build PCs from Scratch

Course Contains:

- A Self-Study Course Manual
- A Video on Basic PC Assembly and Configuration
- A Video Tutorial on the MicroScope Software
- MicroScope Diagnostic Software - Limited Edition (25 uses.)

01-920

(plus $20.75 ship & hand) **$239.95**

Electronics Circuits & Components Learning CD

This popular Electronic Circuits & Components CD covers all of the basic knowledge needed to get students started in electronics and it does so in a unique and effective style.

This CD assumes no prior knowledge of electronics and it makes full use of animations, sound & graphics to take users from first principles to simple circuits.

Topics Covered: 1. Fundamentals 2. Passive Components 3. Semiconductors 4. Passive Circuits 5. Active Circuits

01-909.....**$49.95** (plus $5.25 SH)

BONUS - FREE Parts Gallery CD!

This CD contains a library of different types of electronic components and it's *FREE* with every 01-909 purchase!

Digital Electronics CD Tutorial

This Digital Electronics tutorial provides a detailed introduction to the principles and practice of digital electronics along with an introduction to microprocessor based systems.

A gallery of common digital ICs and photographs of digital circuit applications is also included.

Most techinicians in a computer or electronics related field need to have at least a basic understanding of digital electronics. *Learn all you can about them!*

01-922.....**$49.95** (plus $5.25 SH)

Send your order to CIE Bookstore: 1776 E.17th Street, Cleveland, Ohio 44114
CA, HI and OH residents must add sales tax.
Source code BS 20.

Order on line at www.ciebookstore.com or call (800) 321-2155

Write in 62 on Reader Service Card.

USING VOLTAGE REFERENCE AND TEMPERATURE SENSOR ICs (Part 2)

by Ray Marston

Ray Marston shows – in this second episode of this three-part series – how to use various popular 'current source' and 'temperature sensor' ICs.

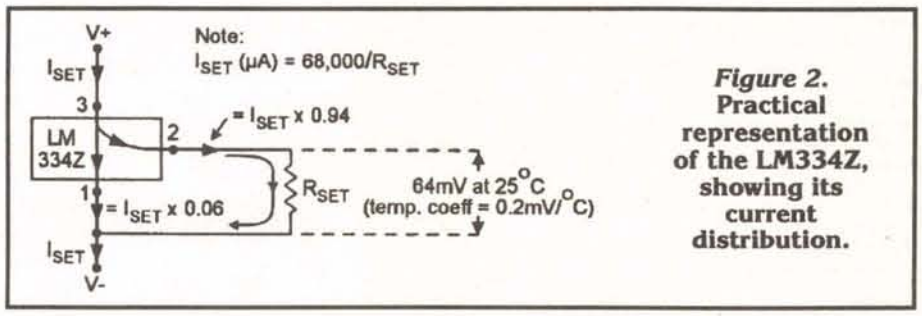
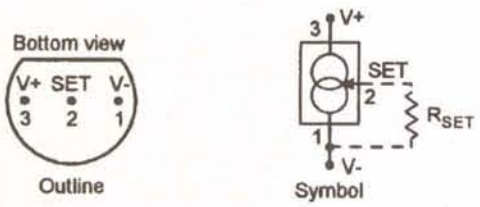


Figure 2. **Practical representation of the LM334Z, showing its current distribution.**



Operating voltage range	= 1V to 30V
Operating current range	= 1µA to 10mA
Current regulation accuracy	= 0.02%/V (typical)
Current sensitivity	= 0.068V/R_{SET}
Temp. coefficient	= 0.33%/°C
R_{SET} value (at 25°C)	= 68,000/I(µA)

Basic specification

Figure 1. **Basic details of the LM334Z adjustable current source IC.**

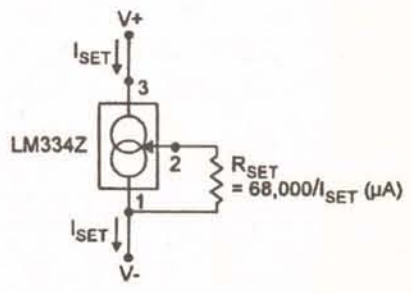


Figure 3. **Basic LM334Z floating or 'two-terminal' current source circuit.**

Last month's opening episode of this three-part series dealt exclusively with popular voltage reference ICs. This month's episode begins by describing practical applications of the popular LM334Z adjustable current source IC, and then goes on to present practical application data on three popular temperature sensor ICs manufactured by National Semiconductor.

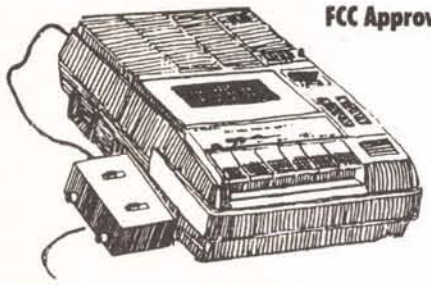
'CURRENT SOURCE' ICs

So far, this mini-series has dealt only with 'voltage reference' ICs. The present section moves on from this subject and deals with 'current source' ICs. These devices act as constant-current generators or sinks, and pass a fixed or preset operating current that has a value that is virtually independent of variations in the device's operating voltage. Such devices are widely used in precision bias networks and linear ramp generators, etc.

The best known commercial-grade 'current source' IC is the LM334, which is manufactured by National Semiconductor and is available in a variety of sub-types, in various packaging styles. The best known of these is the LM334Z, which is housed in a three-pin TO-92 plastic package (an almost identical device, the LM 334N, is available from SGS Thomson). The LM334Z can be regarded as a high-performance 'floating' constant-current generator that can be used with supplies in the 1V to 30V range and can have its operating current set to any value between 1µA and 10mA via a single external resistor (R_{SET}). *Figure 1* shows basic details of the LM334Z.

TELEPHONE LISTENING DEVICE WITH 12 HR. RECORDER

FCC Approved



Record telephone conversations in your office or home. Starts automatically when phone is answered, records both sides of phone conversation. Recorder stops when phone is hung up. $99.95 + $7 shipping. For telehone listening device separately $19.95 + $2 ship.

For comprehensive 50 page catalog of Micro Video, VHF transmitters,Surveillance, and Counter-surveillance and much more! Send $3.00

Call 321-725-1000

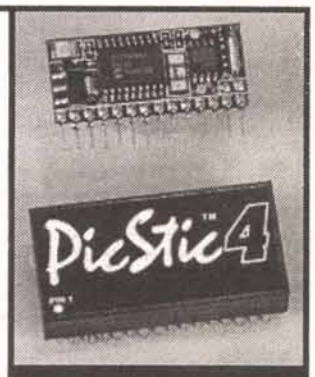
USI CORP

P.O. Box N2052 Melbourne,FL 32902

COD'S OK

Circle #120 on the Reader Service Card.

Honey, I shrunk the COMPUTER!



PicStics are like BASIC Stamps® on steroids. They have more speed, more parallel I/O, more code and data space, and more neat features like a real-time clock, 12-bit ADC, and 12-bit DAC.

As low as $29

Call for a catalog or visit our Web site today.

www.micromint.com

Micromint, Inc

740 Florida Central Pkwy., Longwood, FL 32750

(800) 635-3355

(407) 262-0066

BASIC Stamp is a registered trademark of Parallax, Inc.

Circle #122 on the Reader Service Card.

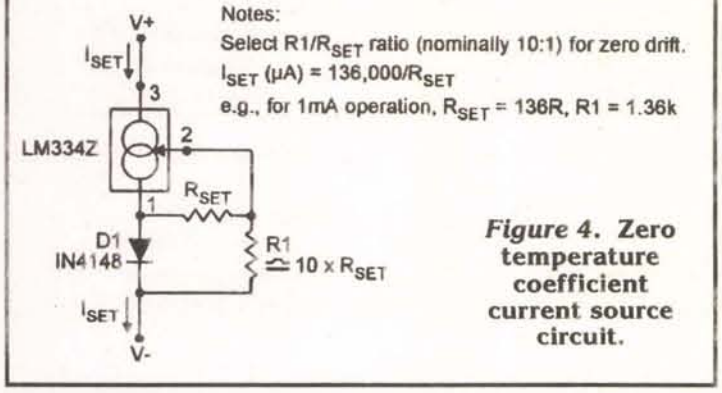


***Figure 4.* Zero temperature coefficient current source circuit.**

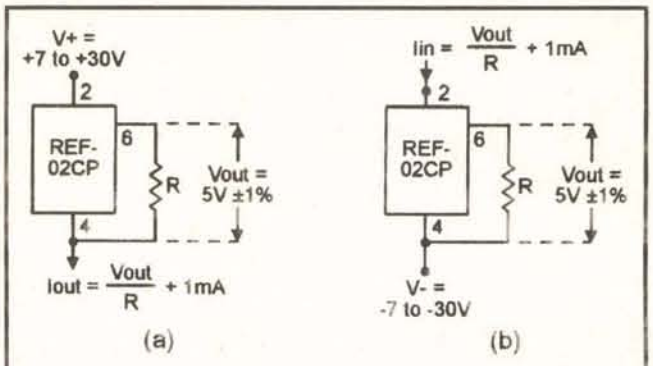


***Figure 6.* Ways of using the REF-02CP IC as (a) a constant current source or (b) a constant current sink.**

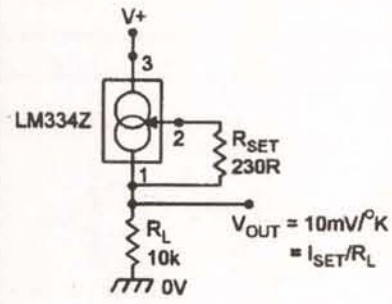


***Figure 5.* Degrees-Kelvin (°K) temperature-to-voltage converter circuit.**

***Figure 7.* Temperature sensor IC selection chart (National Semiconductor 'commercial-grade' devices).**

Parameter	LM34CZ	LM35CZ	LM335Z
Temp. range	-40°F to +230°F	-40°C to +110°C	-40°C to +100°C
Spot accuracy (typ.)	±0.8°F at +77°F	±0.4°C at +25°C	±2°C at +25°C
Range accuracy (typ.)	±1.6°F	±0.8°C	±4°C
Output scale	10mV/°F	10mV/°C	10mV/°K
Supply voltage range	5-30V	4-30V	N.A.
Quiescent current	70µA	60µA	0.4-5mA

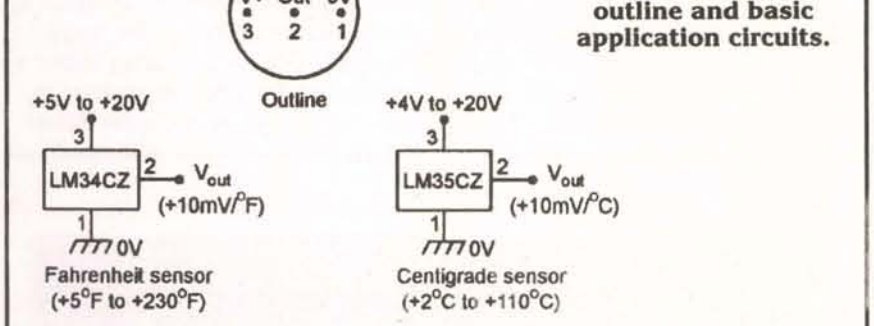


***Figure 8.* LM34CZ/LM35CZ outline and basic application circuits.**

Note that the LM334Z symbol in *Figure 1* perhaps gives a deceptive impression of the device's operation. A more accurate representation of the device action is shown in *Figure 2*, where the following points should be noted. The I_{SET} current flowing into the LM334Z via pin 3 splits within the device, with only six percent of it flowing to the negative rail (as a 'bias' current) via pin 1, and with the other 94 percent flowing to the negative rail via pin 2 and R_{SET}. At 25°C, a voltage of 64mV is developed across R_{SET} (between pins 2 and 1), and this voltage has a temperature coefficient of +0.2mV/°C. Thus, I_{SET} is temperature-sensitive, and at 25°C has a value (in µA) of 68,000/R_{SET}.

Figure 3 shows the basic way of using the LM334Z as a floating 'two-terminal' current source (or current sink).

The R_{SET} value determines the IC's operating (I_{SET}) current, using the formula shown in the diagram. Spot R_{SET} values are 6k8 at 10µA, 680R at 100µA, 68R at 1mA, and 13R6 at 5mA. Note that, since identical currents flow into the circuit from the positive rail (the 'sink' current) and out of it towards the negative rail (the 'source' current), the circuit can be used as either a constant-current sink or a constant-current source.

Figure 4 shows how the above circuit can be modified, with the aid of D1 and R1, to eliminate the temperature sensitivity of the current source (D1 must share the thermal environment of the LM334Z).

Finally, *Figure 5* shows how the LM334Z can be used as a temperature-to-voltage converter that gives an output of +10mV/°K.

Before leaving the subject of 'current source' ICs, note that the REF-02CP voltage reference IC that was described in last month's article (and also the REF-01 and REF-03 types, also described last month) can be used as a precision current source or current sink by using it in the basic ways shown in *Figure 6*.

TEMPERATURE SENSOR IC BASICS

Temperature sensor ICs are simple devices that convert temperature directly into voltage. National Semiconductor is a leading producer of ICs of this type, and *Figure 7* shows basic details of the three most popular low-cost 'commercial-grade' devices in their range. Here, the LM34CZ and LM35CZ are precision 'micropower' devices that give outputs proportional to °F and °C, respectively, and the LM335Z is a simple trimmable device that gives an output proportional to °K. The rest of this month's article gives practical application details of these three ICs.

LM34CZ/LM35CZ circuits

The LM34CZ and LM35CZ are housed in three-pin TO-92 packages, and are designed to consume quiescent currents of only a few dozen microamps, to minimize internal heating effects; both ICs can, however, produce output drive current of up to 10mA. *Figure 8* shows the outline and basic application circuits of these ICs; note that these simple single-supply circuits give minimum temperature

B/W Board
Hi-Res Cameras
From $32.00

Hi Power
Infrared
Board
Cameras From
$39.00

All Cameras Shipped With PlugnPlay Cable With RCA Video Out and Standard DC Barrel Plug. Enclosed Cameras Come With Miniature Mounting Bracket. All Products On This Page Use 12 Volts DC Standard!! Please Call **1-800-903-3479** For More Information or Email: *Sales@IntellicamSystems.Com*

www.INTELLICAMSYSTEMS.com

High Res *Color*
Enclosed Pinholes
From $99.00

Enclosed B/W
Pinholes
From $39.00
Color Board
Pinholes
Starting At
$79.00

Your New Headquarters For 2.4 Gigahertz Wireless Solutions. All of our wireless transmitters are FCC compliant. Outputs vary from 10mw (no license required) to law enforcement grade high power outputs. Some outputs do require certain FCC licenses.

Camera and
Transmitter About
The Size Of A
lighter!!
Supermini COLOR
CCD Wireless **Starts**
at $139.00

Our 24-100
Wireless
Transmitter is 4
channel switchable
and is the worlds
smallest PLL
Crystal Controlled
TX. Available.
Starts at $49.00

Matching 4 Channel
Receiver Available
Starting at $49.00

$136.88 In Quantity

4 Inch TFT Color
Display
With Audio And Image
Reverse.
RCA Connectivity
Operates On Standard
12 Volts DC. 89,622
Pixels For Excellent
Resolution. Ideal
For Setting Up Video
Surveillance Systems.
Compatible With All
Video Game Consoles.

From Board Level Pinhole Cameras To Specialty Underwater Color Infrared Cameras, We have what you're looking for at true wholesale prices. Call us now at **1-800-903-3479.** Dealers Always Welcome.

Circle #124 on the Reader Service Card.

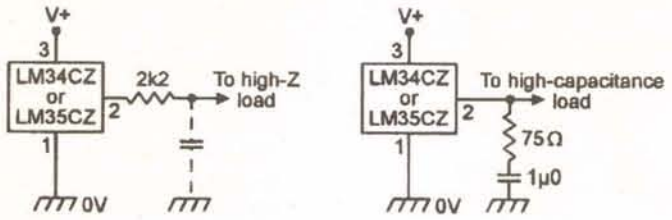


Figure 11. **Methods of driving high-capacitance loads.**

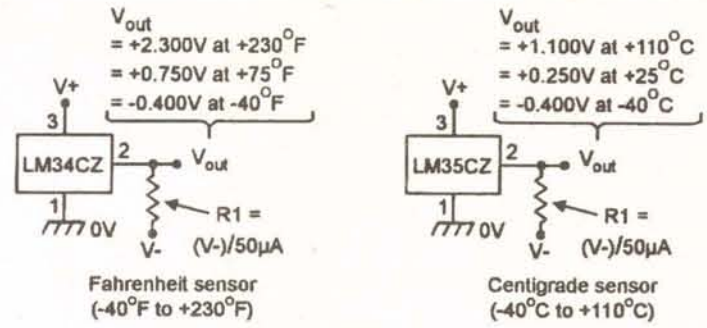


Figure 9. **LM34CZ/LM35CZ full-range temperature sensor circuits.**

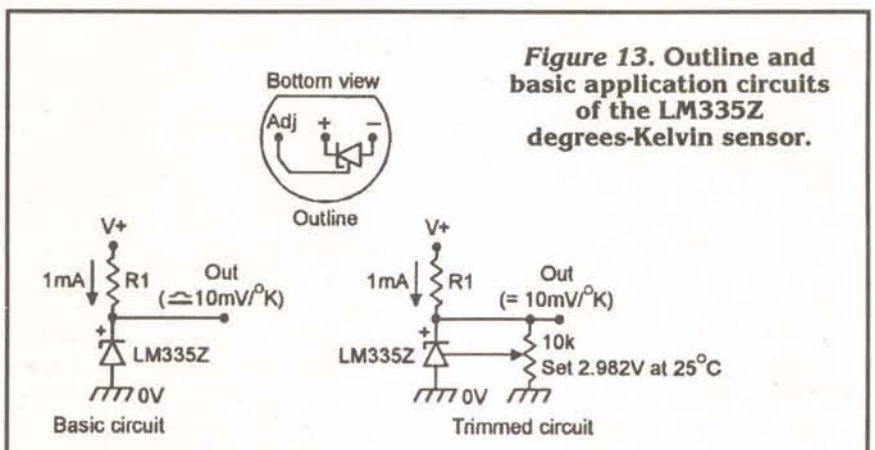


Figure 13. **Outline and basic application circuits of the LM335Z degrees-Kelvin sensor.**

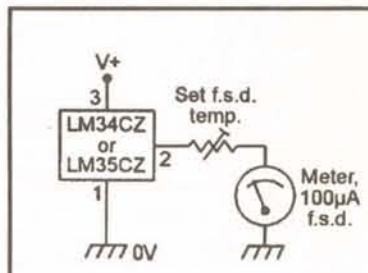


Figure 12. **Analog °F or °C meter.**

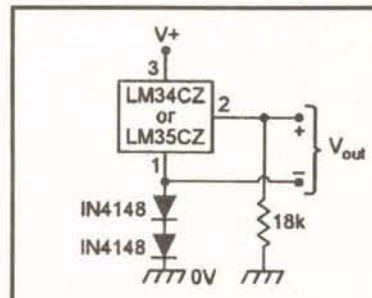


Figure 10. **Single-supply full-range temperature sensor.**

readings of +5°F or +2°C.

The LM34CZ and LM35CZ ICs can be made to give full-range outputs (i.e., to give temperature readings down to -40°F or -40°C) by using the two-supply connection shown in *Figure 9*, or the simulated two-supply connection in *Figure 10* (in which a bias voltage of about 1.2V is generated across the two series-wired IN4148 silicon diodes and is applied to pin 1 of the IC).

Note that (like most micropower ICs) the LM34CZ and LM35CZ tend to become unstable if their outputs are directly loaded by capacitive loads greater than a few picofarads (pFs). This problem can easily be overcome by feeding such loads in either of the ways shown in *Figure 11*, using either a series resistor (2k2 or greater) in the output line, or a simple Zobel-

Celebrating our 17th Year Of Service !!

COLLIMATING LENS

This economical collimating lens assembly consists of a black anodized aluminum barrel that acts as a heat sink, and a glass lens with a focal point of 7.5mm. Designed to fit standard 9mm laser diodes. Simply place diode in the lens assembly, adjust beam to desired focus, then set with adhesive.

STOCK#		1-9	10-24	25+
LSLENS	Lens Assembly	24.99	23.74	21.37

DIODE/TRANSISTOR TESTER KIT

This dynamic tester allows checking of transistors & diodes in circuit. Identifies NPN or PNP transistors. Checks all types, small or large power. Identifies anode or cathode of diodes.

STOCK#	1-9	10-24	25+
DT100K	24.99	23.74	21.37

ANTI-STATIC FOAM CLEANER

A thick, foaming cleaner for use in static sensitive applications. Safe for plastics and fiberglass. Use on computer cases and all office equipment. Also cleans soft fabrics. 5 oz. aerosol can.

STOCK#	1-9	10-24	25+
SB1102	1.99	1.89	1.70

EPROMS

STOCK#	1-24	25-99	100+
2716	2.99	2.84	2.56
2732	4.49	4.27	3.84
2732A-20	5.49	5.22	4.70
2764-20	5.39	5.12	4.61
2764-25	4.49	4.27	3.84
2764A-20	3.49	3.32	2.99
2764A-25	2.99	2.84	2.56
27C64-15	2.99	2.84	2.56
27256-15	4.79	4.55	4.10
27C256-15	2.99	2.84	2.56
27512-25	3.09	2.94	2.65
27C512-25	2.99	2.84	2.56
27C010-15	2.79	2.65	2.39
27C020-15	3.49	3.32	2.99
27C040-12	5.49	5.22	4.70
27C080-12	10.99	10.44	9.40

Popular I.C.'s

STOCK#	1-24	25-99	100+
7400	.39	.37	.33
74LS00	.19	.18	.16
4017	.29	.28	.25
7805T	.33	.31	.28
7812T	.33	.31	.28
LM317T	.49	.47	.42
LM386N-1	.33	.31	.28
NE555N	.24	.23	.21
LM741N	.24	.23	.21
NE5532N	.55	.52	.47
68HC705C8P	8.99	8.54	7.69
8749	17.99	17.09	15.38
62256LP-10	2.79	2.65	2.39
2816	2.79	2.65	2.39

FM MICROPHONE KIT

Transmit your voice on any FM radio. Range up to 1000'. Case included

STOCK#	1-9	10-24	25+
K30	15.99	15.19	13.67

What Do We Have ?

- I.C.'s
- Oscillators
- Crystals
- Diodes
- Tools
- Laser Diodes
- Vises
- Resistors
- Capacitors
- Connectors
- Trimpots
- Kits
- Vises
- LED's
- Transistors
- And more!

GADGETEER'S GOLDINE

This exciting collection of electronic projects features experiments ranging from magnetic levitation and lasers to high-tech surveillance and digital communications.

- By Gordon McComb

STOCK#	1-9	10-24	25+
TB3360	24.99	23.74	21.37

- Order Line — (800) 824-3432 • International — (724) 495-1230 • Fax Orders — (724) 495-7882
- Technical Support — (724) 495-1231 • No Minimum Order – (Orders under $20 subject to $ 5 charge) •UPS 3 day, Blue, Red, & Fed. Ex. Shipping Available (Call for charges) • PA Res. Add 7 % Sales Tax •Open Mon-Fri 9:00 AM - 5:00 PM (EST) • Corporate Accounts / Quantity Discounts Available •We accept M/C, VISA, Discover & American Express with no surcharge • Call For FREE Catalog ($2.00 Outside U.S.)
- We Carry A Complete Line Of Electronic Components • Email - unielect @ aol.com

Visit us on the web ! www.unicornelectronics.com

FREE SHIPPING!! on pre-paid orders

Unicorn Electronics
1142 State Route 18
Aliquippa, PA 15001

Circle #119 on the Reader Service Card.

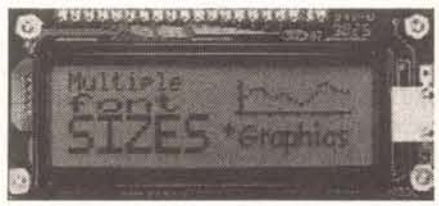
Serial in, graphics out.

Almost *too* easy.

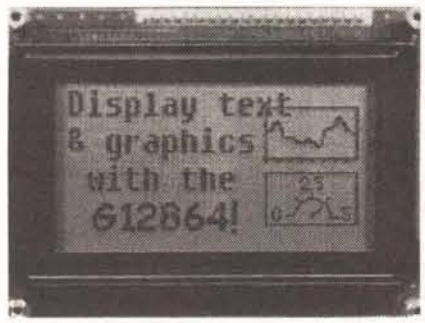
These serial displays take RS-232 at 2400 or 9600 baud and produce stunning text and graphics on a supertwist LCD screen. See our complete line at www.seetron.com. All models are in stock for immediate delivery.

G12032
120x32-pixel LCD
SGX-120L ***$99.00***

Same size as 2x16 text LCD
Editable font(s) in 4 sizes
Up to 6 screens in EEPROM
Easy terminal protocol



(3.2 x 1.4 in.)



(3.7 x 2.8 in.)

G12864
128x64-pixel LCD
$199.00 BGX-128L-I

Large, sharp LCD
Editable font(s)
Up to 14 screens in flash
Separate text, graphics layers
DB9 connector built in
AC adapter jack built in
Easy terminal protocol

www.seetron.com

Scott Edwards Electronics, Inc. ph 520-459-4802 fx 520-459-0623 nnv@seetron.com

Circle #123 on the Reader Service Card.

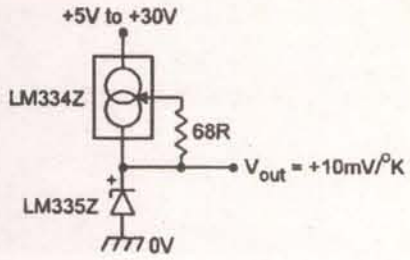


Figure 14. **Operation from a wide-range supply voltage.**

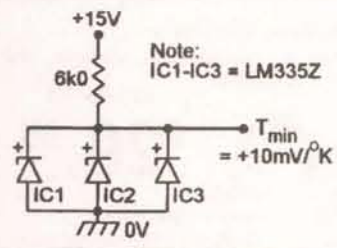


Figure 15. **Multi-input minimum-temperature sensor circuit.**

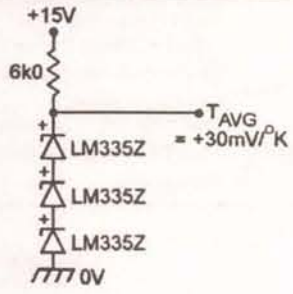


Figure 16. **Multi-input average-temperature sensor circuit.**

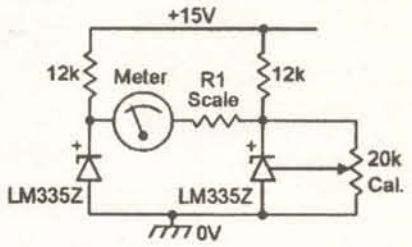


Figure 17. **Differential temperature analog meter circuit.**

type load across the output.

Finally, note that these ICs can be used as an analog thermometer by connecting their outputs to a reasonable sensitive moving-coil meter via a suitable 'ranging' resistor, as shown in the basic circuit in *Figure 12*, in which the IC is shown driving a 100µA moving coil meter.

LM335Z circuits

The LM335Z acts like a temperature-sensitive trimmable zener diode that gives an output of +10mV/°K (e.g., 2.732V at 0°C, or 2.982V at +25°C).

Figure 13 shows the IC's outline and simple ways of using the device in either the basic or the 'trimmable' (precision) mode; note in these circuits that the R1 value is chosen to set the IC's current at about 1mA.

Figure 14 shows how the basic circuit can be modified for 1mA operation (via the LM334Z constant-current generator) when using a wide-range supply.

Figure 15 shows three LM335Zs used in a circuit that gives an output proportional to the lowest of three sensed temperatures, and *Figure 16* shows a circuit that gives an output proportional to the average of three independent readings.

Finally, *Figure 17* shows how two sensor ICs can be used to make a differential temperature analog meter. The meter should be a center-reading (50µA-0-50µA) 100µA type; the CAL control is initially set to give zero reading when both ICs are at the same temperature, and R1 is chosen to set the desired full-scale differential reading. **NV**

Next month, Ray completes the series with a further selection of how to use popular 'temperature sensor' ICs.

"CQ? CQ?
Is *everyone* out there?"

The SG-2020
All the ham frequencies and much more...

The leader in portable **HF-SSB** operation. The SG-2020 puts out **maximum power** even under mismatched loads and varying SWR conditions. The **high-visibility** LCD display and crystal clear receiver sensitivity make the SG-2020 perfect for any type of application - **fixed, mobile, portable or aviation**. Built to military specifications and weighing **only 4½ pounds** (2 kg), the SG-2020 can be placed in a location where space is precious and **minimal current consumption** is needed. Legendary SGC **quality and reliability** at an incredibly low price.

Full HF Range ~ RX/TX ~ 1.8 to 30 MHz ~ 20 Watts ~ 12.6 VDC

1-800-259-7331
ww wsgcworld.com

"No Compromise Communications"

SGC

13737 SE 26th St., Bellevue, WA 98005 USA
Phone (425) 746-6310 Fax (425) 746-6384
E-mail: sgc@sgcworld.com

MADE IN USA

1971-2001

Circle #121 on the Reader Service Card.

ELECTRONIX EXPRESS

Visit Our Website At http://www.elexp.com

WELLER SOLDERING STATION – *MODEL WLC 100*
- Variable power control (5 to 40 watts)
- Replaceable heating element
- Quality light-weight pencil iron

$36.95

LOWEST PRICE 20MHZ

INSTEK OSCILLOSCOPE
MODEL GOS-620
Dual Channel – *20MHZ*
(INCLUDES PROBES)
$299.00

SCOPE PROBE 60 MHZ $12.95
SWITCHABLE X1, X10

DIGITAL MULTIMETER
32 Ranges – 3½ Digit
MODEL MY-64 $27.95
AC/DC Volt/Current, Res. Cap., Frequency. Rubber Holster Included

INSTEK FUNCTION GEN.
WITH INT/EXT FREQ. COUNTER
3 MHz, Digital Display
MODEL 8216 $199.00

ALLIGATOR LEADS $2.10
SET OF 10

SWITCHES
Mini Toggle SPDT ..... 50¢ ea.

SOLDERING IRON 3-WIRE
HIGH PERFORMANCE
#060501 $5.25

RSR—TELECOMMUNICATIONS TRAINER
HANDS-ON TELEPHONY, LAN, CATV EXPERIENCE WITH ONE SELF-CONTAINED UNIT

T-Comm Trainer (TCM-100)	$199.95
Lab Manual / Work Book	26.95
Component and Supplies Kit	37.95
Tool Kit	119.95

Only $199.95
MODEL TCM-100

SOLDERLESS BREADBOARD
830 tie points. MB102PLT model features 3 binding posts and aluminum backplate.

Part No.	1-9	10+
MB102	5.95	5.00
MB102PLT	8.95	8.00

PRESS-N-PEEL
PC Board Transfer Film

PNP Blue 5 Sheet	$9.90
PNP Wet 5 Sheet	9.90
PNP Blue 20 Sheet	28.95
PNP Wet 20 Sheet	28.95

RESISTOR KIT
1/4W 5% film. 5 pieces each of 73 values. 365 pieces total.
$3.95

MOTION DETECTOR
$2 ea. – 10 For $15

PAD-234
DIGITAL/ANALOG TRAINER
Complete portable workstation. Variable and fixed power supplies, function generator, digital I/O, rugged design, high impact case.

Assembled	Kit
$150.00	$110.00

HIGH QUALITY TOOLS
With Cushion Grips and Return Spring
Needle Nose Pliers $2.95 | Wire Stripper $1.50 | Diagonal Cutter $2.95

DC POWER SUPPLIES
MODEL HY3003 – DIGITAL DISPLAY
Variable output, 0-30 VDC, 0-3 Amp $89.00
MODEL HY3003-3 – TRIPLE OUTPUT
Two 0-30 VDC, 0-3 Amp variable outputs plus 5V 3A fixed. Digital Display. $215.00

LM555 10 Min.	22¢ ea.
LM741 10 Min.	27¢ ea.
74LS00 10 Min.	18¢ ea.
7805 Regulator 10 Min.	30¢ ea.
2N3904 10 Min.	6¢ ea.
PN2222 10 Min.	6¢ ea.
Red LED T 1¾ 10 Min.	6¢ ea.
Green LED T 1¾ 10 Min.	7¢ ea.
Yellow LED T 1¾ 10 Min.	8¢ ea.
Photo Cell 10 Min.	65¢ ea.
100K Pot., 1" Shaft PC Mt. 10 Min.	15¢ ea.

FREE CATALOG
MORE Low-Priced Items In Our FREE *256-Page Catalog*

TERMS: Min. $20 + shipping. School Purchase Orders, VISA/MC, Money Order, Prepaid. NO PERSONAL CHECKS, NO COD. NJ Residents: Add 6% Sales Tax.

In NJ: 732-381-8020
FAX: 732-381-1006
365 Blair Road • Avenel, NJ 07001-2293
800-972-2225
http://www.elexp.com
email: electron@elexp.com

Circle #125 on the Reader Service Card.

USING VOLTAGE REFERENCE AND TEMPERATURE SENSOR ICs (Part 3)

by Ray Marston

Ray Marston shows — in this final installment of a three-part series — how to use a further selection of popular 'temperature sensor' ICs.

The first two articles of this three-part mini-series presented practical 'application' information on popular voltage reference ICs, current source ICs, and on three popular temperature sensor ICs manufactured by National Semiconductor. This month's concluding episode gives practical usage information on four popular and widely available temperature sensor ICs manufactured by TelCom Semiconductor.

Miscellaneous Temperature Sensor ICs

Several companies other than National Semiconductor manufacture popular types of temperature sensor ICs. The best known of these is TelCom Semiconductor, who produce four very popular ranges of such devices.

Two of these devices — the TC02 and the TC03 — are precision temperature-to-voltage converter ICs that generate a linearized output voltage that is proportional to the IC's temperature and has a slope of 10mV/°C.

The other two devices — the TC07 and the TC622 — act as presettable thermal switches with complimentary logic-type outputs that change state when the IC's temperature goes above or below preset limits, which can be accurately set via one or two external resistors.

The rest of this article presents practical usage information on these four devices.

The TC02 and TC03 (TelCom Semiconductor)

The TC02 and TC03 are precision temperature-to-voltage converter ICs that generate a linearized output voltage that is proportional to the IC's temperature and has a slope of 10mV/°C. Figure 1 lists the basic operating parameter details of the two devices.

The TC02 IC is specifically designed for use with a simple single-ended DC supply with an output voltage in the range 3V to 12V, and acts as a precision converter over the -20°C to +125°C temperature range. Its output voltage equals (10mV x °C) + 500mV, and is thus 300mV at -20°C, 750mV at +25°C, and +1500mV at +100°C. Figure 2 shows the basic application circuit of the TC02 IC.

The TC03 IC is specifically designed to generate an output voltage that is directly proportional to temperature at a rate of 10mV per °C, over the -20°C to +100°C temperature range; its output voltage is thus 200mV at -20°C, 250mV at +25°C, and +1000mV at +100°C. Figure 3 shows the IC's basic application circuits. If the IC is to be used only at temperatures within the range 0°C to +100°C, the simple single-ended circuit of Figure 3(a) can be used, but if it is to be used at temperatures down to 20°C, the dual-supply circuit of Figure 3(b) must be used. In the latter case, the negative supply rail (V-) needs a value of at least -1.5V, and bias resistor R1 needs a value (in kilohms) of 20 x the V- value, e.g., 30k at a V- value of -1.5V, or 90k at -4.5V.

Parameter	TC02	TC03
Supply voltage range	3.0V to 12V	2.2V to 12V
Supply current (typ.)	40µA	40µA
Output source current (max.)	1mA	1mA
Thermal range	-20°C to +125°C	-20°C to +100°C
O/P voltage at -20°C	+300mV	-200mV
O/P voltage at +25°C	+750mV	+250mV
O/P voltage at +100°C	+1500mV	+1000mV
Non-linearity	±0.8°C	±0.8°C
Average O/P slope	10mV/°C	10mV/°C

Figure 1. Basic operating parameter values of the TC02 and TC03 temperature sensor ICs.

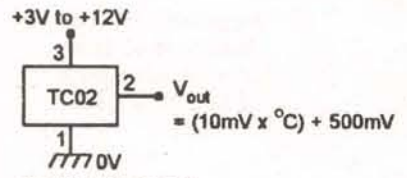


Figure 2. Basic TC02 application circuit.

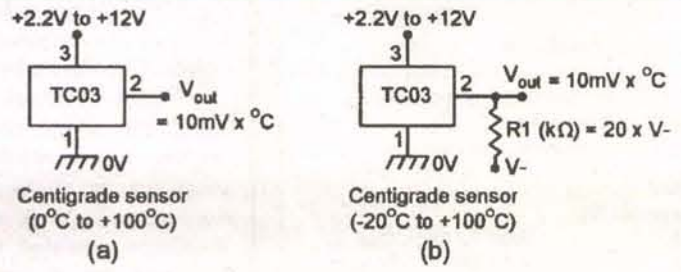
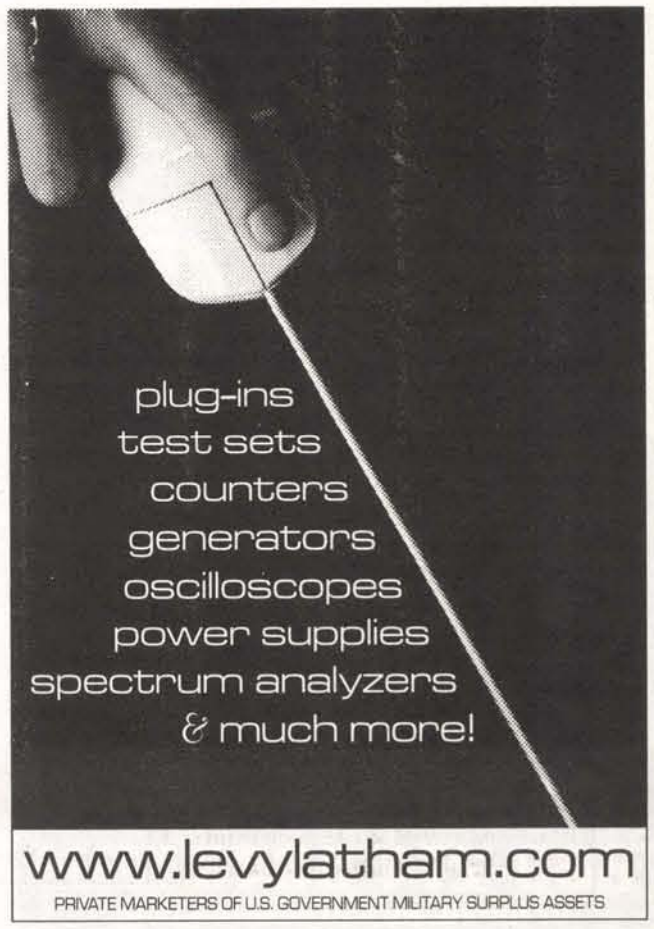


Figure 3. Basic TC03 application circuits (see text).



Circle #119 on the Reader Service Card.

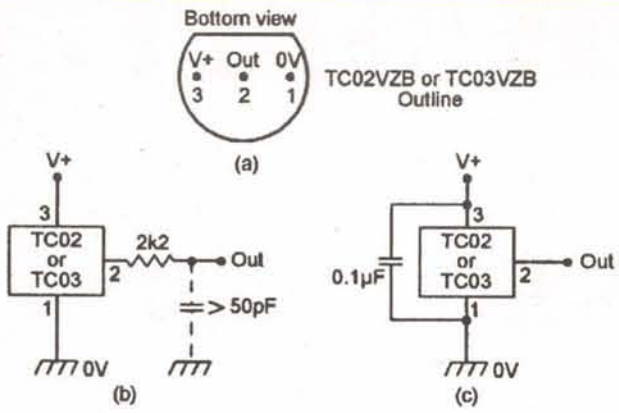
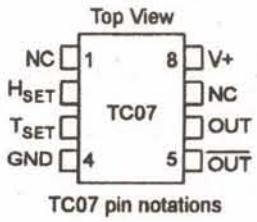


Figure 4. Additional TC02/03 usage data (see text).

Part No.	Package	Temp. Range
TC07COA	8-pin SOIC	0°C to +70°C
TC07CUA	8-pin MSOP	0°C to +70°C
TC07EOA	8-pin SOIC	-40°C to +85°C
TC07EUA	8-pin MSOP	-40°C to +85°C
TC07VOA	8-pin SOIC	-40°C to +125°C
TC07VUA	8-pin MSOP	-40°C to +125°C

TC07 type-number coding



TC07 pin notations

Figure 5. TC07 type-number coding and pin notations.

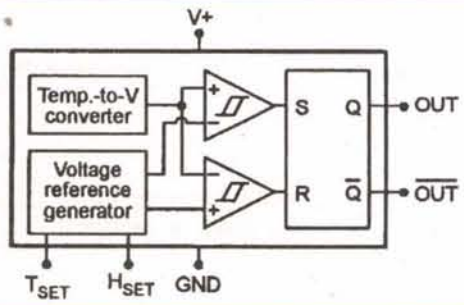


Figure 6. Block diagram of the internal circuitry of the TC07 IC.

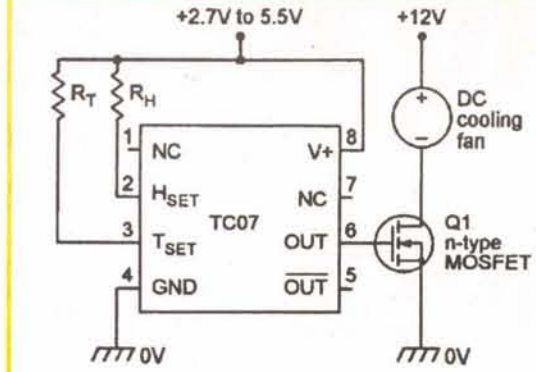


Figure 7. TC07 IC used as an automatic cooling fan controller.

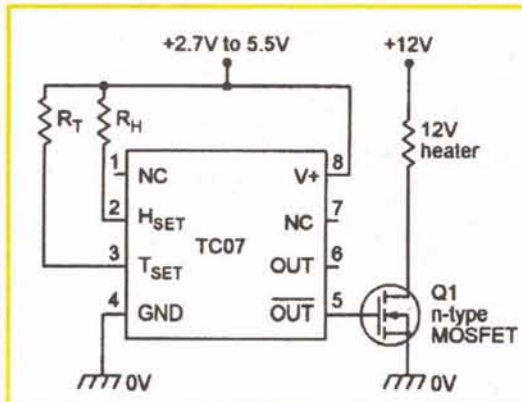


Figure 8. TC07 IC used as an automatic 12V heater controller.

The TC02 and TC03 are widely available in a TO-92 packaging style, in which case their device numbers carry a 'VZB' suffix, as indicated in the package outline diagram of Figure 4(a). When using the TC02 or TC03, note that they have a very limited ability to drive capacitive loads. If they are used to drive loads greater than 50pF (between the output and ground), wire a 2k2 or greater resistor in series with the IC's output, as shown in Figure 4(b). If the IC is used in an electrically noisy environment, wire a 0.1µF decoupling capacitor between the IC's V+ and GND pins, as shown in Figure 4(c).

The TC07 (TelCom Semiconductor)

The TC07 IC is a resistor-programmable solid-state thermal switch with complimentary logic-type outputs; it is designed to be powered from a 2.7V to 5.5V DC supply and consumes a typical quiescent operating current of 130µA. The device is intended mainly for use as an automatic temperature controller in power supply units and computers, etc., and its trip (activating) temperature and hysteresis value (deactivating temperature) can each be set ('programmed') via a single external resistor.

The TC07 is produced in two different eight-pin packaging styles (SOIC and MSOP), each with an option of three different temperature operating ranges. The TC07 is thus available in a total of six sub-variants, each denoted by a three-letter suffix to the basic TC07 part number, as shown in the table in Figure 5, which also shows the pin notations that apply to the TC07.

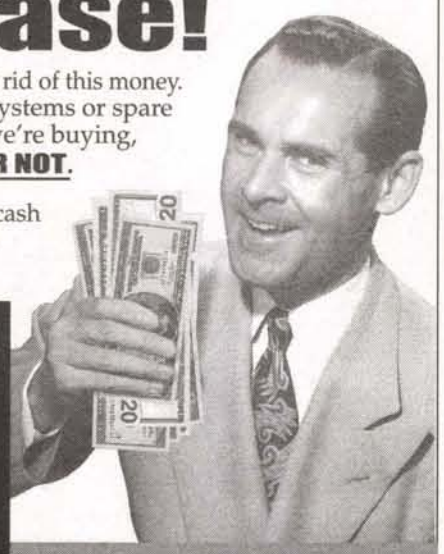
Figure 6 shows — in block diagram form — the basic internal circuitry of the TC07. The IC houses a temperature-to-voltage converter of the basic TC02/03 type, and its output is fed to one input on each of a pair of Schmitt voltage comparators, which each have their other input driven by the output of an externally resistor-controlled dual voltage reference generator. The outputs of the two Schmitts are fed to the inputs of a SET-RESET flip-flop, which provides anti-phase logic-type outputs (Q and not-Q); when the outputs are active; Q is high and not-Q is low. These states are reversed when the outputs are inactive. The basic IC action is such that both outputs become active when the IC temperature exceeds a preset T_{SET} (temperature) value, and remain active until the IC temperature falls below a preset H_{SET} (hysteresis) value, at which point, the outputs become inactive.

Figure 7 shows a basic way of using the TC07 as an automatic cooling fan controller, which activates the fan if the IC temperature exceeds a 'T_{SET}' value determined by R_T. Once activated, the fan remains on until the IC temperature falls below an 'H_{SET}' value determined by resistor R_H. Alternatively, Figure 8

Take Our Cash... Please!

We've gotta get rid of this money. If you've got systems or spare parts to sell, we're buying, **WORKING OR NOT.**

We'll swap ya cash for drives and RAM, too!



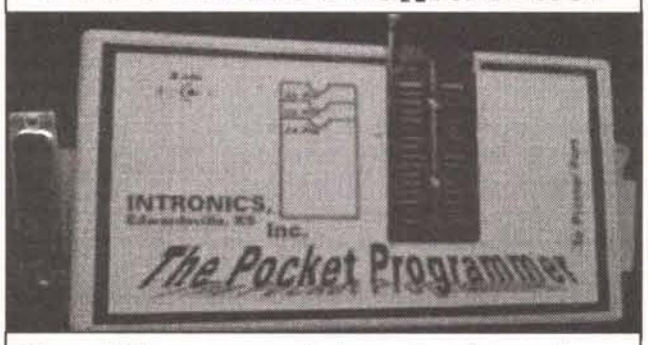
Compaq
H-P
IBM
Toshiba
Sony
Apple

Contact Arthur today at: **Pre-Owned Electronics** INCORPORATED

800-274-5343 X4310

or email: ajr@preowned.com DTS0089

The Pocket Programmer



The portable programmer that uses the printer port instead of a internal card. Now with easy to use Windows software that programs E(E)prom, Flash & Dallas Ram. 25/27/28 & 29 series from 16K to 8 Megabit with a 32 pin socket. Adapters available for MCU's 874X, 875X, Pic, Atmel, 40-Pin X16, Serial Eprom's, PLCC, Bi-Prom's, Eprom Emulator to 32K X 8 and More.... **Only $149.95**

Same Name, Address & Phone # for 19 Years.... Isn't it Amazing ?

Intronics, Inc.
Box 12723 / 612 Newton St.
Tel. (913) 422-2094
Fax (913) 441-1623

Add $7.00 COD
Add $6.00 Shipping

WWW.IN-KS.COM Visa/MC/Amex/Disc

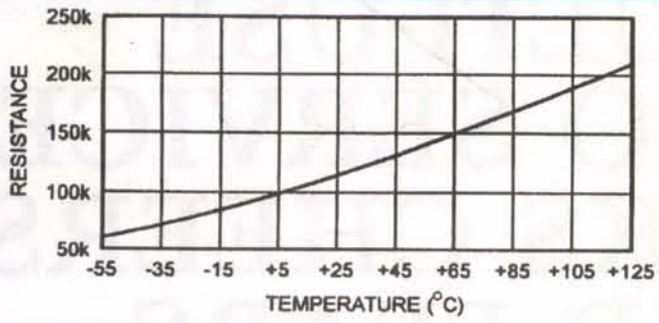


Figure 9. Programming-resistor values vs. °C temperature.

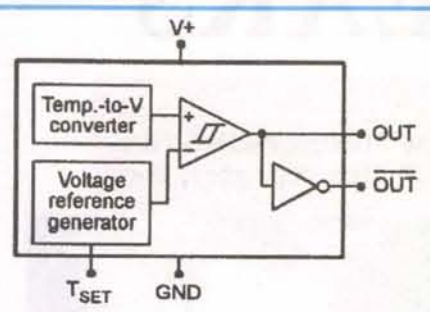


Figure 10. Block diagram of the internal circuitry used in the TC622/624 ICs.

Parameter	TC622EAT	TC622VAT
V+ range	4.5V to 18V	4.5V to 18V
Supply current	200µA typ.	200µA typ.
Temp. range	-40°C to +85°C	-40°C to +125°C
Temp. accuracy	±1°C typ.	±1°C typ.
Trip point hysteresis	2°C	2°C

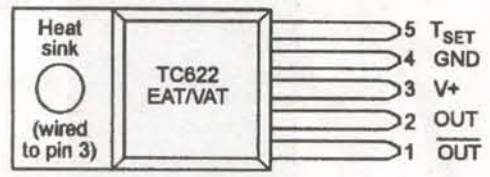


Figure 11. Basic specifications and package details of the TC622EAT/VAT ICs.

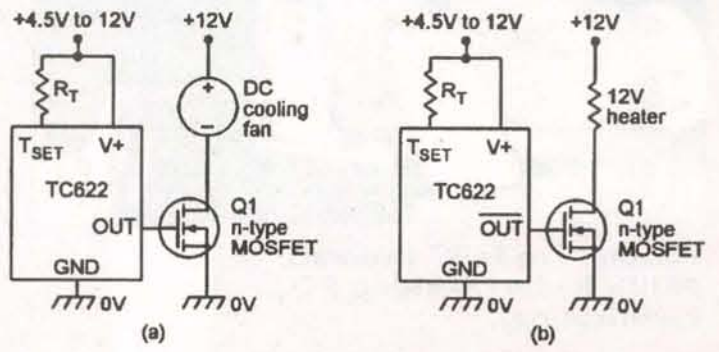


Figure 12. Basic ways of using a TC622 IC to automatically control (a) a cooling fan or (b) a 12V heater.

shows the circuit modified for use as an automatic heater controller, which activates a 12V heater unit if the IC temperature falls below an 'H_{SET}' value determined by resistor R_H. Once activated, the heater remains on until the IC temperature exceeds a 'T_{SET}' value determined by R_T.

The trip temperature values of the TC07 are determined by the values of R_T and R_H, and these values are determined (with a typical precision of ±1%) by the formula:

$$R = 0.6\ (T + 273.15)\ 2.13$$

where R is the required R_T or R_H value in ohms, and T is the required T_{SET} or H_{SET} trip temperature in °C. Thus, for a T_{SET} value of 50°C, R_T needs a value of 132.8k, and for an H_{SET} value of 30°C, R_H needs a value of 115.9k.

As an aid to calculating R_T and R_H values, Figure 9 shows a basic resistance versus temperature graph for the TC07. Note that the graph has a mean slope of 0.85kW/°C over the temperature range 0°C to 100°C. Thus, in the above example (in which H_{SET} is 20°C lower than T_{SET}), R_H must be 17k smaller than R_T. It is important to note that, in the TC07, the H_{SET} temperature must be at least 5°C lower than the T_{SET} temperature value.

The TC622 (TelCom Semiconductor)

The TC622 IC is a dual-output thermal switch in which the trip temperature value can be set via a single external resistor. The device can be regarded as a simplified general-purpose semi-precision version of the TC07 and has a fixed (built-in) thermal hysteresis value of 2°C.

The basic TC622 IC is available in various packaging styles and with a variety of voltage and temperature operating ranges. 'Standard voltage' types can use 4.5V to 18V DC supplies and carry the basic TC622 type number followed by a three-letter suffix that denotes the IC's package style and thermal operating range. 'Low voltage' types can use 2.7V to 4.5V DC supplies and carry a TC624 type number followed by a three-letter suffix that denotes the IC's package style and thermal operating range. A total of 14 sub-variants of the basic TC622/624 IC are available, and all use the same basic internal circuitry, which is shown in block diagram form in Figure 10.

The most popular devices in the TC622 range are the TC622EAT and the TC622VAT, which are each housed in five-pin TO-220 packages with an integral heatsink (which is internally connected to the IC's pin 3 'V+' terminal). Figure 11 shows the basic specifications and package details of these two particular ICs.

The TC622 devices are used in the same basic ways as the TC07 ICs, but without the use of an R_H resistor. Figure 12(a) shows a basic way of using a TC622 IC as an automatic cooling fan controller, which activates the fan if the IC temperature exceeds a 'T_{SET}' value determined by R_T. Once activated, the fan remains on until the IC temperature falls 2°C below the 'T_{SET}' value. Alternatively, Figure 12(b) shows the circuit modified for use as an automatic heater controller, which activates a 12V heater unit if the IC temperature falls 2°C or more below a 'T_{SET}' value determined by R_T. Once activated, the heater remains on until the IC temperature exceeds the 'T_{SET}' value.

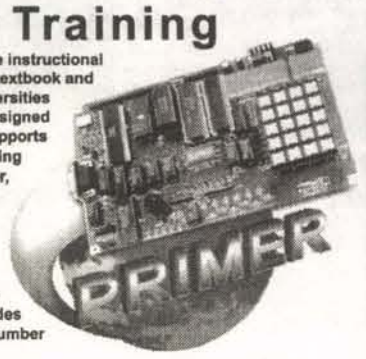
Finally, note when using the TC622 IC that the R_T value is determined in exactly the same way as in the case of the TC07 IC, using the formula:

$$R_T = 0.6\ (T + 273.15)\ 2.13$$

as described in the 'TC07' section of this article. **NV**

Microprocessor Hands-On Training

The PRIMER Trainer is a flexible instructional tool featured in a Prentice Hall textbook and used by colleges and universities around the world. Ruggedly designed to resist wear, the PRIMER supports several different programming Languages including Assembler, Machine Language, C, BASIC, and FORTH. A comprehensive Instruction Manual contains over 25 lessons with several examples of program design and hardware control. The Applications Manual provides theory and sample code for a number of hands-on lab projects.



Application Projects Include:
- Scan Keypad Input & Write to a Display
- Detect Light Levels with a Photocell
- Control Motor Speed using Back EMF
- Design a Waveform Generator
- Measure Temperature
- Program EPROMs
- Bus Interface an 8255 PPI
- Construct a Capacitance Meter
- Interface and Control Stepper Motors
- Design a DTMF Autodialer / Remote Controller

The PRIMER can be purchased as an unassembled kit ($120) or as an assembled/tested kit ($170). Upgrades provide battery-backed RAM and PC connectivity via an RS232 serial port (shown in picture). Additional options include a heavy-duty keypad (shown in picture) and a 9V power supply -- see our website. Quantity discounts are available. Satisfaction guaranteed.

Since 1985 OVER 16 YEARS OF SINGLE BOARD SOLUTIONS

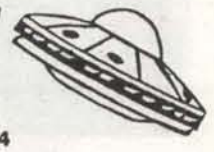
EMAC, inc.

Phone 618-529-4525 Fax 618-457-0110
2390 EMAC Way, Carbondale, Illinois 62901
World Wide Web: http://www.emacinc.com

Circle #120 on the Reader Service Card.

When Visiting Disney World And Sea World. . .
Come To The World Of Electronic Surplus!

SKYCRAFT
PARTS & SURPLUS, INC.
ORLANDO, FLORIDA



Located At The Intersection Of I-4 And Fairbanks Avenue.

Self-Service Retail Outlet Featuring Commercial And Government Electronic Surplus Including:

- ★ WIRE
- ★ SWITCHES
- ★ RESISTORS
- ★ TRANSISTORS
- ★ TRANSFORMERS
- ★ TEST EQUIPMENT
- ★ NI-CAD BATTERIES
- ★ COAX
- ★ RELAYS
- ★ HARDWARE
- ★ CAPACITORS
- ★ PANEL METERS
- ★ CIRCUIT BOARDS
- ★ INTEGRATED CIRCUITS

★ ★ ★ ★ ★ ★ ★ ★ ★

We Buy Surplus Electronic Parts — *FAX your list.*

www.skycraftsurplus.com
FAX 407/647-4831
PH 407/628-5634
P.O. BOX 536186
ORLANDO, FLA. 32853-6186

HOURS:
Monday - Friday 8:30-6:00
Saturday 8:30-5:00